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(57) Abstract

The invention relates to a method of destruction of solid dielectrics and semiconductors, and may be used in building, cementing, chemical, or mining and processing industries and others branches of industry. The present invention provides a method of destruction of solid dielectrics and semiconductors, which allows to increase the capacity of traditional crushing equipment and reduce power consumption for crushing processes, or provide higher degree ofmaterial dispersion at the same power imputes. A method of destruction of solid dielectrics and semiconductors by means of mechanical influence on the material under treatment has been proposed using a destruction means and physical influence. Physical influence is effected by applying sign–alternative frequency–modulate electric potential to a mechanical means and materials under treatment placed in its working space.

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Method of destruction of dielectrics and semiconductors

Technical field

The present invention relates to a method of destruction of a solid substance, for example, dielectric or/and semiconductor materials, in particular building inorganic astringents and cementings, mineral fertilizers, minerals, and may be used in building, cementing, chemical, ore mining and processing industries and others branches.

Background of the invention

Technological processes of material destruction such as crushing (the size of particles obtained by crushing being from 300 mm to 1 mm) and grinding (particle size being from 1000 micron to less then 40 micron) are wide spread in industry. In worldwide industrial manufacture the substantial portion of energy resources are spent for crushing and grinding. For example, about 3,000 million Kwatt.h of electric power is consumed each year for clinker crushing in the USA, and about 5,000 million Kwatt.h - in Russia. Thus, there is a problem of high power consumption in crushing industry in connection with the fact that fuel method holds the predominant position in world electric power structure, in one side, whilst thermoelectric power stations, cause a significant environment pollution, in the other side.

In chemistry, known are physical-chemical methods of strength reducing (see, Fridrikhsberg D.A. "Course of colloid chemistry", Leningrad, Khimia, 1984), for example, the so-called "wet crushing", or crushing with surfactants, preventing from aggregation of small fractions and promoting the "wedge forcing" effect, which permit obtaining high dispersion products. However, in this case, specific power consumption increases due to necessity of subsequent drying a final product. Moreover, another drawback of these methods is

the presence of surfactants in a final product.

In the latest time, attempts have been made to solve the problem of increasing the effectiveness of solid crushing which result in creating alternative methods of solid material destruction. However, they also have significant limitations.

Known is a method of electric-hydraulic blow (Russian Patent Application 92015077, "Electric-hydraulic method of destruction of solid substances", Bulletin of Inventions No.7, publ. 10.03.95). According to this method, the material to be destroyed is placed in a liquid and a high-voltage electric discharge is effected in this liquid. The drawbacks of the known method are the necessity of using the liquid, that may be inadmissible or undesirable in some applications and the use of high-voltage equipment.

Known are method and apparatus for slurry cleaning of an autoloader drum (RU 2052295, Bulletin of Inventions No.2, publ. 20.01.96). The method includes supplying water under pressure, demolition and slackening of slurry, and removal of slurry using an auxiliary instrument, such as a camera with electric discharge device. The method requires using an auxiliary equipment and subsidiary expenditure of electric power.

Known is a method of high voltage electric impulse destruction of concrete and reinforced concrete products (Russian Patent Application No. 93035219, Bulletin of Inventions No.2, publ. 20.01.96). The method includes using a system for high-voltage discharge, it is complicated and requires significant energy consumption.

The nearest prior art to the proposed invention is a method of destruction of solid dielectrics and semiconductors by mechanical attack on the material using destruction means and electrical-physical forces (USSR Authors Certificate No. 1659100, B02C 18/19, publ. 30.06.91). The method partially increases crushing effectiveness and reduces power

consumption. However, physical attack is applied by means of electrical ultra-high frequency radiator in direct contact from both sides of a piece of material to be destroyed. The method has very limited application because it is not adapted for crushing and grinding with the use of a crusher or other traditional means of crushing.

Thus, known methods either required application of liquid media with significant power imputes, or have very limited application to solve the problems exist in destruction technology.

Summary of the invention

The object of the proposed invention is a method of destruction of solid dielectrics and semiconductors, the method providing the increase of productivity of conventional crushing equipment and offering reduction of power consumption of crushing processes or providing the higher dispersion degree of material at the same power imputes.

When investigating processes of solid material destruction, authors have discovered the possibility of intensifying processes of crushing and crumbling of dielectrics and semiconductors under the influence of the sign-alternative frequency-modulated potential, induced by, for example an electronic or electro-mechanical generator. Conventionally, high-energy fields or high-tension current passing through a material to be destroyed are considered to be necessary conditions of material destruction. However, as it is shown in the present invention, the effective and rapid destruction can be achieved in the absence of electric current, only due to influence of sign-alternative frequency-modulated electrical potential. The discovered phenomenon can be partially explained on the grounds of electro-physycal nature of solid material destruction. During the solid destruction, the energy is partially spent for generating of electric charges both on solid surface owing to creation of the double electric layer of contact nature, and in solid

volume - as a display of the direct piezoelectric effect. Taking into account this fact, it may be supposed that mentioned processes are put down under the influence of variable (alternative) electric fields on materials being destroyed; and owing to the phenomenon of inverse piezoelectric effect and electrostiction in said materials the processes of destruction may be intensified. Assimilating the microdefects of solid structure to an elementary plane capacitor, it can be as well assumed the existence of "wedge forcing" effect of alternative electric field.

Thus, the object of the present invention is achieved by providing a method of destruction of dielectrics and semiconductors by means of mechanical attack on material to be destroyed of a destroying means and physical influence. The physical influence is effected by applying sign-alternative frequency-modulated electrical potential either to the means for mechanical destroying, or to a material under processing which is placed in a working space of said means. The sign-alternative frequency-modulated electrical potential may be supplied from electronic or electro-mechanical generator. A characteristic feature of the proposed method is also a fact, that the sign-alternative frequency-modulated electrical potential may be supplied both to the means for destroying and material to be destroyed by the same electrode.

According to the present invention, frequency-modulated alternative electric field has carrier frequency in range from 10 Hertz to 50 kHertz, preferably from 30 Hertz to 10 kHertz. Applied potential is from 0.5 to 300 V, preferably from 1 to 100 V.

In this case, if material to be destroyed is crushed in a conical crusher, the sign-alternative frequency-modulated electrical potential may be applied both to the crusher's working body and to the said material. As a conical crusher a cone-inertial crusher can also be used. If the material is

crushed in a mill, for example, in a ball mill, a sign-alternative frequency-modulated electrical potential may be applied to a frame of a mill and to the said material.

As a material to be destroyed in this invention is used dielectrics and semiconductors selected from the group including bituminous and brown coals, shungits, granites, limestone, oxides of metals, ores of non-ferrous metals and ferrous metals, building inorganic astringents and cementings, mineral fertilizers and so on. Inorganic astringents are selected from the group including cement clinker, mixtures of slaked lime and quartz sand, alumina and so on. Ores of non-ferrous and ferrous metals are selected from the group including iron ore, copper-nickel sulphide ores, silicate-nickel ores, phosphorites and apatites.

The next step is to crush the solid materials in a conventional crushing and crumbling means with applying the sign-alternative frequency-modulated electrical potential provided by single electrode (SE). Due to particles of this material gain a momentary sign-identical charge, the repulsion of particles and the intensive destruction "from inside" occur. As a result, a sudden increase of thin fractions output has been observed, while crushing homogeneity has increased, process time reduced, and therefore, power consumption reduced also. The above mentioned technical effect can not be achieved by known methods of material destruction and known ways of physical influence, since they are based on the action of the alternative current or fields created by two electrodes. It means, that the lines of field strength of such a field are closed. In this case, no conditions are created for particles to gain the same charges, in contrast with the case of a single electrode potential. In addition, the use of a sign-alternative frequency-modulated electrical potential strengthen the destruction action of intensive lattice vibrations, which are caused by momentary change of particles

charge into inverse one.

Brief description of drawings

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, without loss of generality, to the accompanying drawings in which:

Fig. 1 shows the influence of the sign-alternative frequency-modulated electrical potential on the mass part Q (%) of fractions of aluminium oxide having different particle size d (mm). A material has been crushed in a laboratory cone-inertial crusher at invariable process time.

Fig. 2 shows mass distribution Q/d of shungite particles grounded in a vibration mill against equivalent diameters d (micrometers) with the use of sign-alternative frequency-modulated electrical potential and without use.

According to one embodiment of the present invention, the material to be destroyed is put in a means for destruction, for example, a crusher, a mill, a runner, a disintegrator, whereupon sign-alternative frequency-modulated electrical potential is applied to said means. The processes of crushing and crumbling may be carried out in laboratory equipment or industrial equipment, variable electric fields may be created in a working space of said means. Generation techniques and processes of frequency modulation of electric potential, machinery engineering and safety engineering are discussed in detail in a technical literature available for a specialist in the art (see, e.g. Shevchenko A.O. "AutoSummary of Master's Thesis", S.Pb., 1995,26 p.p., Technological-Technical University; Schekotova E.A. "AutoSummary of Master's Thesis", S.Pb., 1995, 24 p.p., Technological-Technical University) and aren't considered in this description.

The change of equipment output was estimated against time of predetermined size grade. Mechanical-chemical

characteristics, such as specific surface area, compression, chemical activity of cementing substances, were estimated by well known methods in the art (see, e.g. Figurovskiy N.A. "Segimentologichesky analys", Ed. Rebinder P.A., Moscow-Leningrad, 1948, 332 p.p.; Butt U.M., Timashev V.V. "Practicheskie raboty po khimicheskoy technologii vayzhushchikh", Moscow, High School, 1973, 504 p).

The invention will now be in detail with reference to the following non-limiting examples.

Example 1.

A process of crushing a clinker "BC" has been examined in a cone-inertial crusher KID-10 (ÊÈÄ-10) available from joint-stock company "Mechanobr-Technogen", St.Petersburg, Russia. The supplied potential was 14 V, carrier frequency of electric field was in range from 19 to 1990 Hz. The following data were obtained:

- capacity of the crusher increased by 15-20 %;
- sieve analysis showed the increase of small fractions more then 2 times;
- specific surface area of crushed clinker has increased by 29 %;
- chemical activity of cementing has increased by 17 %.

Example 2.

A process of production of lime-siliceous cementing was examined in a ball mill in silicates-brick yard of joint-stock company "Buildmaterials", Belgorod, Russia. During the examination, mill operation under the usual regime and under the applied potential were compared. The applied potential was 9 V, carrier frequency of electric field was in range from 31 to 6700 Hz. The results were estimated against the time of cleaning of raw material bunker and lime crushing quality.

Time estimation of bunker cleaning has shown that in the

absence of potential the bunker was cleaned after 130 min, under the potential - after 105 min. Thus, the time change is 19.2 %.

The crushing quality is showed in tables 1 and 2.

Table 1

Test 1: potential 9 V, carrier frequency 31-6700 Hz.

Time	9-20	11-15	13-15	14-00	15-00	16-00
Rest on sieve 800 micron,%	40	36	27,75	35,0	37,5	32,2
Rest on sieve 200 micron,%	8,25	8,5	4,0	5,0	8,5	6,0
Cementing activity,%	40,6	40,6	57,4	46,8	42,0	50,4

Table 2

Test 2: potential 75 V, carrier frequency 9-900 Hz.

Time	9-00	11-45	13-15	14-45
Rest on sieve 800 micron,%	32,5	24,5	24,0	27,5
Rest on sieve 200 micron,%	5,0	3,5	2,5	3,5
Cementing activity,%	42,0	44,0	43,0	57,1

Example 3.

The examination of coal crushing process has been carried out in cheek crusher on Perm Chemistry-Mechanical Factory, Perm, Russia. During testing, the comparison of the traditional regime working of crusher and the working with potential was made. The potential was 48 V, carrier frequency of electric field was in range of 40-9710 Hz. The results are shown in table 3.

Table 3

Fraction composition, mm, %

Time	8	+ 6 - 8	+ 1 - 6	- 1
15-45, 11.04.96	6,1	11,0	65,0	17,9
17-30, 11.04.96	4,8	11,8	65,9	17,5
19-30, 11.04.96	1,6	7,2	71,6	19,6
21-30, 11.04.96	2,8	7,1	74,7	15,4
0-00, 12.04.96	3,5	13,0	69,0	14,5
2-00, 12.04.96	2,0	6,4	73,0	18,6

As a result of testing, the sudden increase of a basic fraction output at the same time of crushing was observed.

Example 4.

The examination of cement crushing process was carried out on equipment of TOURAN PORTLAND CEMENT CO., (Egypt), in ball mill for cement crushing. The potential was 12 V, carrier frequency of electric field was in range from 40 to 4000 Hz. As a result, the following data were obtained:

- mill productivity has increased by 14-22 %;
- sieve analysis showed the increase of small fractions about 1.5 times;
- specific surface area of crushed cement has increased by 20 %;
- chemical activity of cementing has increased by 13 %.

Example 5.

The examination of mineral fertilizer crushing process was carried out on "Phosphorit" plant, Kingisepp, Russia. During test, calcium phosphate was crushed in a ball mill. The potential was 12 V, carrier frequency of electric field

was in range of 45-900 Hz. As a result, the following data were obtained:

- mill productivity has increased by 33 %;
- sieve analysis showed the increase of small fractions about 2.2 times;
- specific surface area of crushed calcium phosphate has increased by 52 %;
- compression (settlement) lowered by 15 %.

The differential curve of particles size distribution is shown in Fig. 1.

Example 6.

The examination of economic minerals crushing process has been carried out in a mining factory, Stary Oskol, Russia. Iron ore was crushed in shaft crusher. The potential was 15 V, carrier frequency of electric field was in range of 6000 Hz. As a result, the following data were obtained:

- productivity of equipment has increased by 23 %;
- sieve analysis showed the increase of small fractions.

The histogram of sieve analysis is shown in Fig. 2.

Thus, the experiments have shown that the proposed method is environment friendly, permits to exclude industrial wastes from environment, and not dangerous for people.

Besides, method does not require large investments in the existing technologies and can be used for any type of destruction equipment.

Claims

1. A method of destruction of dielectric and semiconductor material by means of mechanical attack on the material using a destruction means and physical influence, *characterized in that* the

physical influence is effected by applying sign-alternative frequency-modulated electric potential to mechanical means and materials under treatment placed in a working space of said means.

2. A method according to claim 1, characterized in that the sign-alternative frequency-modulated electric potential is supplied from electric generator selected from electronic or electromechanical generator.

3. A method according to claims 1 or 2, characterized in that the sign-alternative frequency-modulated electric potential is applied to the destruction means through a single electrode.

4. A method according to any one of claims 1 - 3, characterized in that the sign-alternative frequency-modulated electric potential has a carrier frequency from 10 Hz to 50 kHz.

5. A method according to any one of claims 1 - 4, characterized in that the sign-alternative frequency-modulated electric potential has a carrier frequency from 30 Hz to 10 kHz.

6. A method according to any one of claims 1 - 5, characterized in that sign-alternative frequency-modulated electric potential is in a range from 0.5 V to 300 V.

7. A method according to any one of claims 1 - 6, characterized in that sign-alternative frequency-modulated electric potential is in range from 1 V to 100 V.

8. A method according to any one of claims 1 - 7, characterized in that the material under treatment is crushed in a cone crusher, while sign-alternative frequency-modulated

electric potential is applied to its working body and material under treatment.

9. A method according to any one of claims 1 - 8, characterized in that a cone-inertial crusher is used as the cone crusher.

10. A method according to any one of claims 1 - 9, characterized in that the material under treatment is crushed in a mill, for example, in drum-ball mill, while sign-alternative frequency-modulated electric potential is applied to a mill drum and material under treatment.

11. A method according to any one of claims 1 - 10, characterized in that materials under treatment are dielectrics and semiconductors selected from the group including black and brown coals, granites, limestones, metal oxides, ores of non-ferrous metals and ferrous metals, and inorganic materials including building astringents and cementings, mineral fertilizers and others.

12. A method according to any one of claims 1 - 11, characterized in that inorganic buildings are selected from the group including cement clinker, mixtures of slaked lime and quartz sand, alumina and so on.

13. A method according to any one of claims 1 - 12, characterized in that ores of non-ferrous and ferrous metals are selected from group of iron ore, sulphide cooper-nickel ores, silicate nickel ores, phosphorites and apatites.

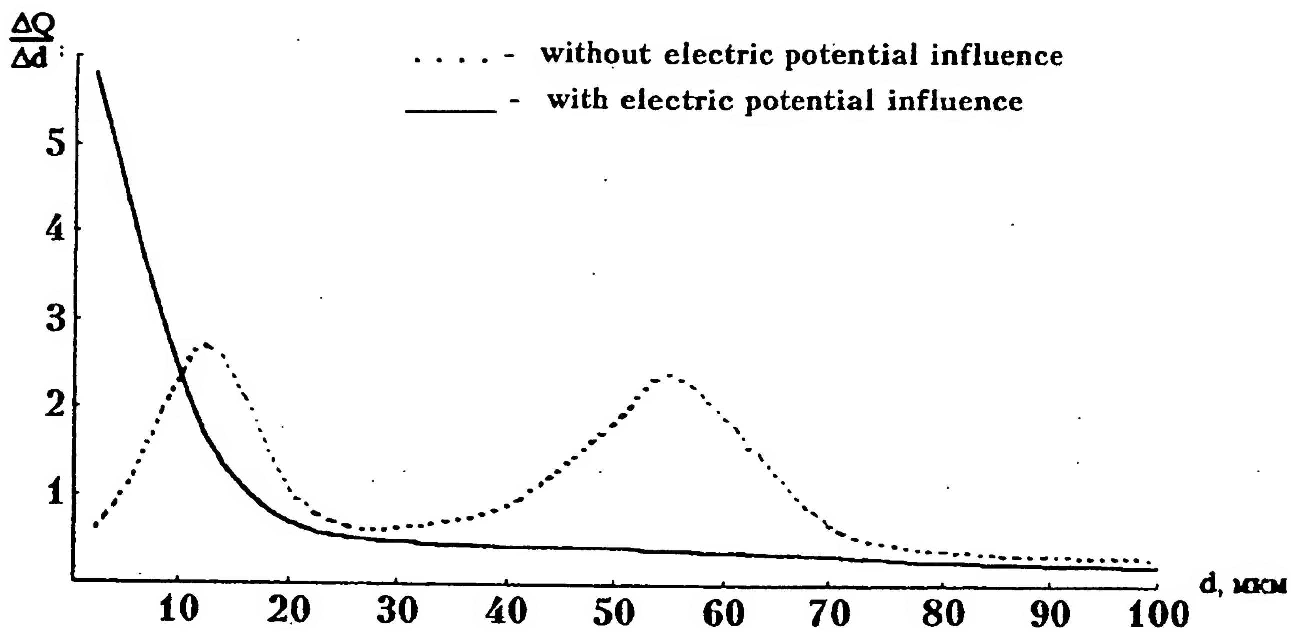
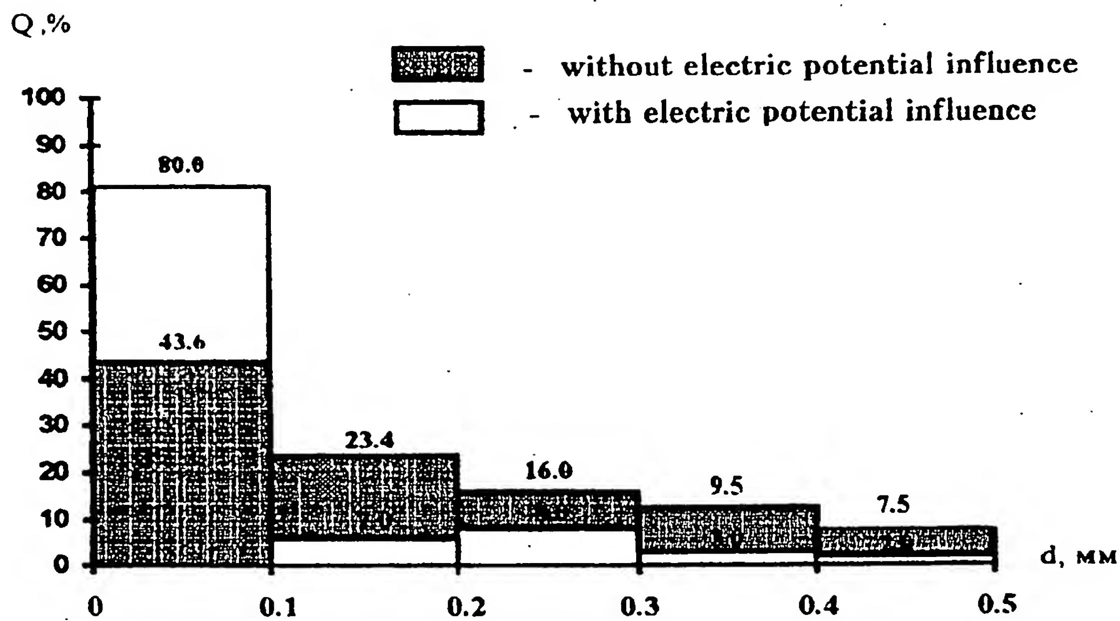

$\frac{\Delta Q}{\Delta d}$
..... - without electric potential influence
_____ - with electric potential influence
5
4
3
2
1
10
20
30
40
50
60
70
80
90
100
d, мкм

Fig. 1


Q ,%
- without electric potential influence
- with electric potential influence
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90
80
70
60
50
40
30
20
10
0
80.0
43.6
23.4
16.0
9.5
7.5
d, мм
0
0.1
0.2
0.3
0.4
0.5

Fig. 2